vary with the seasons, and are therefore not easily comparable with Fitzgerald's.

Russell's formula, however, departs radically from those of Fitzgerald, Carpenter, and Stelling, in that it substitutes the vapor pressure corresponding to the temperature of the wet-bulb thermometer for the vapor pressure corresponding to the temperature of the surface of the water, and adds a term depending upon this same vapor pressure, e_w, in place of the wind velocity term. This latter is dropped, and the equation represents the evaporation with a wind velocity outside the shelter of 7.1 miles per hour, which was the average at the stations where the Piche observations were being made, during June, 1887.

It is evident that this wind velocity will not apply to all parts of the United States for all seasons of the year. Neither will it do to substitute the temperature of the wet-bulb thermometer for the temperature of the water surface, the former being cooler than the latter. No doubt the additive term containing e_w compensates for this in a measure, but we must conclude that Russell's formula does not rest upon as sound a physical basis as do the formulas of Stelling, Fitzgerald, and Carpenter. The term $\frac{1}{B}$ was introduced on account of the wide variations in the value of B at the different stations. It is unimportant when discussing the observations at a single station.

Upon the organization of the Irrigation Survey by the U. S. Geological Survey in 1888, arrangements were made for measuring the evaporation at several points in the arid regions of the United States. It was recognized that the rate of evaporation depended upon the dryness of the air, the temperature of the water surface, and the velocity of the wind at the water surface. An effort was therefore made to measure the evaporation from a water surface having the same temperature as the surface of lakes or reservoirs, and exposed to the same wind velocity. To accomplish this galvanized-iron evaporating pans, three feet square and eighteen inches deep, were floated on the surface of the body of water from which the evaporation was to be measured. The pans were kept nearly full, with the surface of the water in them about on a level with the water outside. The evaporation was at first measured by some sort of gage, but later was determined from the amount of water that was added to bring the surface to the top of a pin projecting from the center of the pan. A record of the water temperature inside and outside the pans was kept. Usually a difference was noted, the inside temperature being higher in the daytime and lower at night. The average is, however, about the same in each. It is not probable that the water in pans is exposed to quite so high a wind velocity as the average over outside surfaces, but to offset this the water in the pan wets the sides, and this increases the evaporating surface. It is therefore assumed that in general the evaporation from a floating pan of this type when kept nearly full represents the evaporation from the outside water surface very closely.

Several of the agricultural experiment stations measure the evaporation from pans, but most of the pans are set in the ground, and for reasons already given their indications are not believed to represent the evaporation from reservoirs and lakes as closely as do those from floating pans.

For the purpose of checking Russell's computed values, the following table has been prepared. In the first two columns are the names of stations and the evaporation computed by Russell. In the following columns are the names of neighboring stations at which measurements of evaporation from water surfaces have been made, the amount of evaporation measured, and the character of the exposure. We are thus enabled to judge of the probable value of Russell's chart.

Annual evaporation.

Russell's formula.		Surface measurements.		
Stations.	Evaporation.	Stations.	Evaporation.	Exposure.
	Inches.		*Inches.*	
Boston, Mass.	34.4	Boston, Mass.	34.78	Beacon Hill Reservoir.
New York, N. Y	40.6	Boston, Mass.	39.11	Chestnut Hill Reservoir, floating pan.
Cheyenne, Wyo.	76.5	New York, N. Y	39.64	Croton Reservoir, floating pan
		Laramie, Wyo	46.30	Ground.
		Fort Collins, Colo.	46.16	Ground.
El Paso, Tex.	82.0	Fort Collins, Colo.	59.50	Computed for reservoir.
		Fort Bliss, Tex.	82.65	Floating pan.
Salt Lake City, Utah.	74.4	Fort Douglas, Utah	42.46	Floating pan.
Fort Grant, Ariz.	101.2	Tucson, Ariz.	75.78	
Prescott, Ariz.	56.0	Tempe, Ariz.	65.00	Floating pan.
Sacramento, Cal	54.3	Clear Lake, Cal	32.38	Floating pan.
		Clear Lake, Cal	33.40	Ground.
Fresno, Cal	65.8	Kingsbury Bridge, Cal.	47.79	Floating pan.
		Kingsbury Bridge, Cal.	59.49	Ground.
Los Angeles, Cal	37.2	Arrowhead Reservoir.	36.60	Ground. (Elev. 5,160 ft.)
San Diego, Cal	37.5	Sweetwater Reservoir.	57.55	Floating pan.

The results above given are not strictly comparable, since the stations are not in all cases identical, and in some cases, especially in California, the reservoirs are at a greater height than the Weather Bureau stations, and in consequence the water surfaces are correspondingly colder. Generally speaking, Russell's results appear to be the higher.

Since Russell's equation was deduced from tridaily observations, it is not applicable to the present 8 a. m. and 8 p. m. observations of the Weather Bureau unless one first applies a correction to the mean of these two observations to reduce it to the mean derived from tridaily observations. The equations of Fitzgerald and Carpenter appear to have a quite general application, provided we know the temperature of the water surface, the dew-point, and the wind velocity. It would seem, therefore, that in the absence of reliable measurements of evaporation from water surfaces, an effort should be made to determine the temperature of water surfaces near Weather Bureau stations, and where the evaporation is measured from tanks sunk in the ground the relation between the temperature of this evaporation surface and the temperature of lakes or reservoirs in the vicinity should be carefully determined.

Seasonal evaporation naturally varies with geographical position. Some of its peculiarities are shown in the following table:

Evaporation in inches.

Month.	Boston, Mass.	Fort Collins, Colo.	Clear Lake, Cal.	Fort Bliss, Tex.
January	0.90	1.50	0.85	2.35
February	1.20	2.00	0.60	2.45
March	1.80	3.50	2.00	6.25
April	3.10	5.00	2.82	7.35
May	4.61	6.50	3.85	10.85
June	5.86	8.00	4.30	11.20
July	6.28	9.50	5.90	9.60
August	5.49	8.50	4.70	9.50
September	4.09	6.50	3.72	9.20
October	2.95	4.50	2.12	6.80
November	1.63	2.50	0.65	4.15
December	1.20	1.50	0.85	2.95
Year	39.11	59.50	32.38	82.65

Several series of evaporation measurements that do not cover the winter season have not been referred to in this paper. While they are of value, the above table indicates the importance to irrigation engineers of making the readings throughout the entire year.

PERPENDICULAR COLD AIR MOVEMENTS AS RELATED TO CLOUD VELOCITY.

By WILLIAM ABNER EDDY, Bayonne, N. J. Dated January 9, 1905.

While flying kites at Stamford, Delaware County, N. Y., in the Catskill Mountains, during a cloudy day threatening rain, I found little wind to sustain the kites and enable them to lift an aerial crossbow, with which I was trying to discharge flying machine models of small diameter. I looked back at the distant mountain side as I held the kites, and I saw what I thought was a moving cloud floating along the mountain side in apparent contact with the surface, near the base of the mountain. I expected every moment that the seemingly approaching mass of mist would enshroud the kites and hide the arrow aeroplanes aloft from view. The wind velocity was probably less than six miles per hour. I waited for the cloud to approach, but it remained stationary for over two hours until rain set in, when its vaporous mass was somewhat thinned. It remained stationary with a light wind blowing right through it, but not moving it. On looking closer at the mountain, I found that a deep ravine cut the mountain side just below the cloud, and it was clear that slightly cooler air had formed a perpendicular upward column, which condensed the vapor directly above the ravine, but nowhere else.

In studying cumulus clouds I find sometimes a perpendicular circular motion like the Ferris wheel, but without much horizontal motion. In summer I have measured the velocity of cirrus clouds, and at times, during a prolonged warm wave, I have found them almost stationary. This is a rare phenomenon, which I believe is partly due to the cold air currents rising into a warmer inert mass of air. In the lower cloud levels I have seen somewhat narrow bands of vapor extending north and south. Their forward edges were often more dense than their rear edges. I think that this indicates that the cold air rises in successions of narrow ridges into a warmer stratum. The uprising long ridge of cooler air makes a dense forward edge fading away to a thinner rear edge. *If the cold ridge of air were motionless, then the warmer air of the upper stratum, even when in active motion, would have floating in it a stationary cloud.* The amount of condensation is limited in the upper warm stratum, and is soon exhausted, as shown by a long, narrow cloud formation. It is evident that the motion of the cirrus clouds from west to east is accompanied by the motion of cold air ridges from west to east and below the level of the cirrus cloud. I think the bands of clouds with heavy forward edges in the direction of motion denote rising ridges of cold air due to storm formations working their way upward from below. It indicates a specially disturbed atmospheric equilibrium. This fact is further shown by the high velocity of the stratified cumulus, sometimes making high speed from the northwest. The significant fact is that, as on the mountain side, a stationary cloud does not necessarily mean stationary air currents. This element, I think, ought to be considered in studying cloud velocities.

Although we can not entirely indorse the explanations of cloud formation given in this article by Mr. Eddy, yet we publish it because we desire to stimulate all our readers to the closest possible study or cloud phenomena until the myriad of details has been thoroughly recorded and satisfactorily explained. Sketches or photographs of cloud forms and the changes that they undergo should frequently be made, noting the direction of the wind and the detailed topography of the ground for a hundred miles to the windward. There are a number of cases on record in which a special cloud formation has been traced back a hundred miles to a distant hill, mountain, or ridge. The atmosphere is as full of eddies and standing waves as is any river at its flood flowing over a rocky bottom in what is called turbulent motion. There are many cases, such as the well-known cloud caps on mountain tops; the helm-bar cloud of the Crossfield Range, as explained in "Espy's Philosophy of Storms"; the tablecloth on Table Mountain, South Africa; in which the wind blows rapidly through a cloud. Aeronauts have been carried in their balloons directly through such clouds, and, of course, special students have always recognized the fact that the motion of a cloud is not necessarily the motion of a current of air. In fact, striated cirri and stratus formations generally move in a direction that is the resultant of the motion of the upper and lower currents between which the clouds themselves are being formed. Anyone who looks down from a hilltop upon the ocean and islands along the coast of Maine may see streaks of fog floating hither and thither, apparently in defiance of the actual movement of the air itself. Cloudy condensation may work backward or sidewise through an advancing mass of air so rapidly that the movement of the front of the cloud has no apparent connection with the movement of the air.

The penetration of a current of cold air into a mass of warm, moist air can, even in favorable circumstances, form only so slight a cloud that we doubt whether it will explain the phenomenon observed by Mr. Eddy. When the wind blows up a ravine on the mountain side the central portion of the current certainly advances much faster than the bottom or sides, and must rise faster, so that it may easily happen that it forms a cloud over the center of the ravine, just as we see clouds forming over the river valleys. It is not proper to say that slightly cooler air, rising perpendicularly, condensed the vapor in the warmer air above the ravine, but that it condensed the vapor within itself by the mechanical cooling of the air due to the work that it had to perform in expanding as it rose so rapidly. Similarly, the cirrus clouds and the long ridges of cooler air spoken of in the latter part of Mr. Eddy's article seem to us to be due to the cooling of ascending streaks and masses of moist air, not to the mixture of cold and moist air; the latter can sometimes form a slight haze, but not a thick cloud.

A CLOUD PHENOMENON AT OMAHA, NEBR.

By Rev. William Francis Rigge, S. J., Creighton University Observatory, Omaha, Nebr.

At about fifty minutes after sunset, on July 18, 1904, my attention was attracted to a cumulus cloud about 10° high in the east-northeast which was pretty strongly illuminated by the sunlight. No other clouds, not even those near the point of sunset, showed the least trace of sunlight. The clouds were in detached bunches and covered about one-tenth of the sky. The brightness of the cloud diminished gradually, but it was still visible a full hour after sunset. The sun set on that day at 7:28 local time, or 7:52 central time.

The data I am enabled to supply are probably insufficient to measure the altitude of the cloud, which seems to have been enormous, since the sun was about 10° below the horizon.

WILLIAM NORRINGTON.

Mr. William Norrington, Observer, died at San Francisco, Cal., December 31, 1904. Mr. Norrington was born in London in 1847 and emigrated to America in time to see service in the civil war, having enlisted in the 16th U. S. Cavalry in 1863. In 1875 he entered the Meteorological Service of the Army, and, with the exception of about two years, continued in that branch of the Government service and in the Weather Bureau until his death. During the last eight years of his life he was on duty at the San Francisco station. He was a valued and faithful employee.

THE INTRODUCTION OF METEOROLOGY INTO THE COURSES OF INSTRUCTION IN MATHEMATICS AND PHYSICS.

[Continued from page 515, Monthly Weather Review, November, 1904.]

By Prof. Cleveland Abbe.

[Read at Chicago, Ill., November 26, 1904, before the Physics and Mathematics Sections of the Central Association of Science and Mathematics Teachers, and reprinted from School Science and Mathematics.]

Mathematics and physics go hand in hand, so closely that